

ON THE TRANSPLANTATION OF LARGE STRIPS
OF SKIN FOR COVERING EXTENSIVE GRAN-
ULATING SURFACES, WITH REPORT OF A
CASE IN WHICH HUMAN AND FROG
SKIN WERE SIMULTANEOUSLY
USED FOR THIS PURPOSE.¹

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CASE :—R. W. æt. 16 years, single, American, colored. Admitted to Methodist Episcopal Hospital, April 10, 1888, two weeks following a burn, the result of the accidental upsetting of a kerosene lamp. Prior to admission the burns had been treated with carbolized oil. On admission, temperature 102° Fahr. Pulse 120. Suppurating surface involving the thickness of the true skin, for the most part, extending from level of crest of ilium downward over both buttocks. That upon the left side reaches to the knee-joint, while upon the right side the middle of the thigh is reached. Laterally the burn extends to the right as far as a line drawn downward from the middle of the crest of the ilium, and on the left as far downward as the anterior superior spine. The greatest length of the burn upon the left side is $17\frac{3}{4}$ inches, and the greatest width 11 inches, with an average length of $14\frac{1}{2}$ inches, and width of $7\frac{3}{8}$ inches. The maximum measurements of the right side are 15 inches in length and $9\frac{3}{4}$ inches in width; average length $10\frac{1}{2}$ inches, and width $6\frac{3}{4}$ inches. Upon the back and anterior surfaces of the thighs there are also a number of smaller burned areas. A raw surface five inches broad extends entirely around the right ankle; on the posterior surface of the left ankle is a burned area five inches long and four inches wide. Estimated total area of burned surface, 247.95 square inches.

May 10. Since admission but little progress has been made

¹Read before the Brooklyn Surgical Society, Nov. 1, 1888.

toward cicatrization. The treatment has consisted of antiseptic irrigation and dressings of liquid tar and ointment of oxide of zinc. Discharge from granulations very profuse. Temperature varying from 101° to 103° F. Patient's strength much reduced since admission. Skin transplantation resolved upon, and so preliminary to this, the surfaces were thoroughly cleansed and dressings of a solution of potassio-mercuric iodide, 1-12000, ordered.

May 15. Operation of skin transplantation. Potassio-mercuric iodide solution washed from surfaces with sterilized salt solution, 6-1000. Instruments and sponges were immersed in this solution. The skin from the back and abdomen of a live frog was then transferred to the granulations over the left buttock. On the right buttock eight strips of white human skin were placed, after the manner of Thiersch. Strapping with oil-silk and gauze compresses wet with the salt solution constituted the dressings. Temperature at time of operation 101.4° Fahr.

May 17. Since the operation the temperature has fallen to 99° Fahr. The strips of frog skin are all in place, firmly attached and exceedingly sensitive. Most of the strips of human skin are likewise in place and of good color; one or two of the latter have been displaced by the movements of the patient.

May 19. The entire skin of three frogs was transferred to the left buttock. The following notes refer to the changes taking place in the transplanted frog's skin.

Second day. Slight slimy discharge, but no change in the color of the transplanted strips.

Third day. A very thin layer came from the surface as the dressings were removed. The color has faded very slightly.

Fifth day. Strips much thinner and color disappearing. The outlying edges of the burned surface show an increased activity, as do also those of a few previously formed centres of cicatrization scattered about the surface and lying adjacent to the transplanted skin.

Tenth day. The color of the grafts has disappeared, and there appears to be left a thin layer of epithelium, covering the surface. To-day a strip of human skin was placed upon the surface of the frog's skin.

June 2. Four days following the placing of the strip of human skin upon the transplanted frog's skin, the former was found to be for the most part necrotic. The areas covered by both frog and human skin are entirely healed. Cicatrization is going on rapidly at the ankles. Patient improved markedly in appetite and strength.

June 30. The transplanted human skin has made a very firm integumentary covering. Where the frog skin was placed, a very deli-

cate and soft surface, fully healed, exists. A small portion of the human skin placed over the frog's skin is found to have retained its vitality. Patient allowed to sit up.

Sept. 1. On the left buttock (site of frog's skin transplantation) two points have broken down, evidently the result of pressure. These show a marked tendency to bleed.

Oct. 1. The broken-down points show no tendency to heal, although patient is again kept in bed with dressing of subnitrate of bismuth. The skin over the right buttock (site of human skin transplantation) is firm and healthy. That over the left is much firmer than when last noted, and is of a reddish hue. A darker color marks the site of the centres of cicatrization which had existed prior to the skin transplantation.

Oct. 18. Firm strips of white skin from arm of the patient were placed over the points where the frog's skin had broken down.

Oct. 25. The last transplanted skin strips have become partially attached. Small portions of two of them have broken down.

Nov. 10. Discharged cured. The frog skin is soft and pliable, and of a reddish hue. The white human skin is firm, and of a darker color than the above, but much lighter than the rest of the patient's body. The portion of skin transplanted from the patient's arm is nearly as dark as the natural color of the patient. The color of the small patches, the result of cicatrization is decidedly that of the negro, as is also that of the cicatrized surfaces about the ankles. There is not the slightest tendency to contraction of the surfaces of repair.

There is no class of deformities more distressing to the patient, or which cause greater annoyance to the practitioner than those the result of cicatricial contraction following burns, or other destructive lesions of the skin in which the deficiency of tissue is made up by the slow, tedious and uncertain process of cicatrization. Here, above all things, is the ounce of prevention worth a pound of cure, and it is in this class of cases that skin transplantation is particularly applicable.

In the case herewith reported, both the method known as Thiersch's¹, and that of transplantation of frog's skin introduced by Baratoux and Dubousquet², were resorted to simul-

¹Archiv. für klinisch. Chirurg. Bd. XVII, 1874.

²Progres Med., No. 15, 1887.

taneously. As will be seen by the notes of the case and its final result, both methods were found to fulfill the requirements, although the subsequent breaking down of a portion of the area covered by the frog's skin suggests the greater stability of transplanted human skin, as compared with that derived from other sources.

Both Thiersch's method and probably that of frog's skin transplantation are applicable to fresh aseptic wounds, and will find application where defects of area are the result of extensive dissection for the eradication of malignant growths in localities where sliding of tissue for the purpose of filling in the gaping wound is not practicable, or, on account of the resulting distortion, undesirable, as for instance, upon the face. After the division of webbed fingers, considerable difficulty is experienced in preventing the granulations from springing up in and obliterating the interdigital angle. This may be obviated by a skin transplantation. The preparation of a fresh wound, when it is in other respects in good condition for primary healing, is completed with the arrest of hemorrhage. Any antiseptic used previously should be washed away with a 6-1000 sterilized salt solution, and a compress wetted with the same is laid firmly over the wound surface, while the skin to be transplanted is being prepared.

In those ulcerated surfaces, characterized by indolent flabby granulations with occasional tufts rising above the general level, and perhaps here and there an island of epidermis, with blue, unhealthy looking edges, it is best to thoroughly curette the entire ulcerated area with the sharp spoon, including in this the thickened fibrous tissue of the edges; even though in the latter an attempt at the formation of an epithelial covering may have been made. Irrigation with a 1-12000 potassio-mercuric iodide solution, and subsequent rinsing with the salt solution is followed by the application of the salt water compresses until such time as the bleeding is arrested. A slight oozing of blood is not a bar to success.

The same method should be employed in cases where, from prolonged attempts at repair, a base or floor of fibrous tissue exists, upon which no granulating tissue develops, owing to

the failure of the vessels to reach its surface. In case the fibrous floor is of considerable thickness, parallel incisions made through the same, about one-eighth of an inch apart, and through its entire thickness, will seem to permit the vessels to furnish the needful nourishment to the over-lying structures from beneath.

Although transplantation may be at once practiced following the curetting in the above class of cases, yet the prospects of success are very much enhanced by allowing granulations to spring up, and applying in the meanwhile antiseptic compresses.

It is of the greatest importance that advantage be taken of the proper stage of the granulating process. In cases characterized by the existence of fresh granulations, with loose structure and profuse secretions, adhesion of the transplanted strip is very much less likely to occur, and frequent failure will occur. Septic conditions are likewise frequent causes of failure. The best results are obtained when the growth of the granulations and the secretions have been markedly restricted and diminished by repeated cauterization, and the use of astringents and compression.

The granulating surface being in proper condition, the most important part of the procedure itself relates naturally to the proper cleansing and disinfection of the part where the defect is to be supplied with new skin, and the surroundings thereof. Great care should be exercised in the selection of an antiseptic, which, while possessing the advantages of potency, shall at the same time be capable of application in such a state of dilution as not to produce poisonous symptoms, even though it be continued in contact with large ulcerating surfaces for several days. For, in order to insure strict asepsis, a disinfectant should be kept in contact with the ulcerated portion for at least two days, and, in some instances, when the early treatment of the burn has been neglected, and the surrounding tissues have become more or less infiltrated, a longer time must be occupied with this stage of the operation. For the purposes of this preliminary disinfection, nothing could meet the requirements more fully, in my judgment, than a 1-12000 solution of the potassio-mercuric iodide. The surrounding

parts having been thoroughly scrubbed with a soft brush and a strongly alkaline soap (common kitchen or laundry soap answers best), the parts are rinsed with a stream of warm water, either distilled, or previously boiled, and squares of gauze of several thicknesses, wrung out of the before-mentioned potassium-mercuric iodide solution, are placed in such a manner as to cover the surface of ulceration and overlap its edges for an inch or more.

Whatever antiseptic is used in the preparation of the ulcerated surfaces, care must be taken previously to the application of the new skin to wash away every vestige of the same. The influence of these more powerful antiseptics is such as to interrupt the changes which occur in the vessels as well as in the blood itself during the first few hours of contact between the transplanted skin and the point of defect. A solution of common salt, in distilled or sterilized water should be used for this purpose. In Thiersch's first trials many failures were attributed to a lack of this precaution. The salt solution was finally chosen from the belief in its tendency to limit free exudation from the ulcerated surface, which would be most threatening to the integrity of the graft, as well as its slight influence upon the blood corpuscles.

The question of the administration of an anæsthetic to the donor is an important one, and must be considered in connection with the particular idiosyncrasy of each individual. Where a number of individuals volunteer to furnish the skin for transplantation, and but a single strip is taken from each, it will be obviously impracticable to administer an anæsthetic to each donor. On the other hand, but few will be found to volunteer to give a large amount of skin, and endure the inconveniences and risks of an anæsthetic, in addition; nor yet to allow themselves to be flayed alive, with all that the term implies. Where the skin is taken from the patient's own person, and, with the exception of cases of very young children with comparatively large surfaces of defect, this is the most satisfactory method, the surgeon must judge as to the necessity for an anæsthetic. There is really but slight pain attending the removal of the skin, and it is best to avoid, if possible, any chance of failure from the presence of even an infinitesimal

portion of ether or chloroform in the blood or tissues. Those from whom I have removed skin for purposes of transplantation, after Thiersch's method, speak of the operation as being only accompanied by a peculiar burning sensation.

The application of an Esmarch's bandage prior to the removal of the skin for transplantation is not advised, save for persons in whom it may be absolutely necessary to save even the few drops of blood lost during the operation. There is some risk to the vitality of the transplanted skin in its use, and wherever possible it should be avoided. Certainly the conveniences to the operator derived from its use are more than counterbalanced by the danger above alluded to.

The arm or thigh from which the strip of skin is to be removed is to be carefully shaved, if it be in a situation in which hair grows, and is to be submitted to a careful process of scrubbing and disinfecting with the 1-12000 potassio-mercuric iodide solution. This in its turn, is to be rinsed away with the sterilized 6-1000 salt solution. There does not seem to be any disadvantage arising from the congested condition of the skin arising from this process of scrubbing; on the contrary, I have looked upon this rather as having a beneficial effect than otherwise.

The best instrument for the removal of the skin to be transplanted is the section razor, used by microscopists, or a common razor with a smooth, concave surface, and a very keen edge. If the part to be operated upon be an arm, or a slender thigh, it should be grasped by the operator's left hand in such a manner that the palmar surface of the latter rests upon the posterior aspect of the former, and the thumb and fingers secure a firm hold by partially encircling the limb. By this manœuvre the skin is drawn tense and prevented from sliding ahead of the razor, or moving from side to side. The blade is to be laid flatwise upon the surface, and, by a sawing motion, commencing at the heel of the blade, the skin is shaved off, the resulting strip, or more properly speaking, shaving resting upon the razor blade, as we proceed. It is best to commence the cut high up and work toward one's self, for in this way a greater steadiness of the hand can be preserved and a strip of uniform thickness throughout its whole length secured. Of

course the strip will vary in thickness in a transverse direction, according to the width of the part operated upon, the depth at which the razor blade is allowed to reach, and the desire of the operator to secure a wide or narrow strip. It is best not to attempt to obtain too much at one cut, for the reason that, although the edges of the strip will always be thin enough, the central portion will be necessarily thicker, and may involve the adipose tissue, a most undesirable addition to the transplanted portion, and an unnecessary infliction of traumatism. At the same time it must be borne in mind that this is not a transplantation of the papillæ alone. The claim that this is all that is necessary to transplant is probably an error. In fact, it is not at all desirable to use slices or slips containing papillæ alone, even if this were possible. According to Thiersch, everything depends upon leading the vessels into the superimposed transplanted skin in the shortest space of time possible. This is very much facilitated by the use of skin of a thickness sufficient to secure the presence of the stroma containing the horizontally lying net-work of vessels. If the blood finds entrance at a point or two of the latter, the vertical vessels are soon supplied from these; but if papillæ alone are used, each of the latter must be supplied directly. So long, therefore, as the subcutaneous cellular tissue space is not invaded, and fat left attached to the strip, the thicker the overlying portion, the more complete the result.

As the strip or sliced-off portion of skin gathers itself upon the surface of the blade, it wrinkles somewhat, and when it is found that so much as will conveniently remain upon the blade without falling off has been obtained, it is best to terminate the cut by turning the edge of the blade away from the surface. The strip is now to be transferred, still lying upon the surface of the razor blade, directly to the place where it is to be engrafted, and there slid off and laid smoothly upon the surface intended for its reception. This manœuvre is best executed by the aid of a pair of dressing forceps, care being taken not to bruise or injure in any way the transplanted skin by injudicious pinching or stretching of the same. Should it adhere to the blade, or become wrinkled or folded upon itself, it may be floated off from the razor by immersing the latter in

a convenient vessel containing the sterilized salt solution, and then spread out, preparatory to transfer, upon the end of the surgeon's disinfected finger.

As each strip is laid in place, it is lightly pressed upon in order to force out any blood from between the parts, as well as to favor its immediate adhesion. The strips should be laid side by side, slightly overlapping each other, or at least as closely together as possible, and such as are adjacent to the edges should project slightly beyond the latter. In this way the entire area of defective surface is to be covered. Where the latter is of such an irregular shape as to necessarily leave intermediate spaces, the granulations will fill in the gap. But when adjoining strips touch or overlap each other, and these are of uniform thickness, the line of junction, after a time, can be scarcely discovered.

The method of dressing is of the greatest importance. Thiersch recommends gauze compresses wrung out of the salt solution and changed daily, the surface being gently irrigated with the warm sterilized salt solution each time. In order to prevent the compresses from clinging to the transplanted pieces and loosening the latter upon removal, it is advisable to first lay strips of sterilized protective or oil silk dipped in the salt solution and arranged as in basket-strapping, over the surface. The compresses of gauze should be sufficient in size to more than cover in the area of the wound surface. Over this is placed a large and thick dry compress, and, when the situation will allow of it, the whole is to be held in place by means of a gauze roller bandage. In case the site of the transplantation is in the neighborhood of a joint, or when from any other reason, especial care must be taken to prevent slipping or sliding of the dressings, and particularly in the case of young children, enveloping the parts in a starch or dextrine bandage, or the application of a splint, or both, will be found to more certainly insure a favorable result. In any event, care must be taken not to apply the bandage too tightly, and, in the case of the extremities, it must not retard the circulation.

In changing the dressings, which should be done daily, each layer must be carefully loosened, after being first gently irrigated and thoroughly soaked with the warm salt solution.

Upon raising the strips of protective or oil silk, the transplanted pieces will be found to be quite adherent, in some instances of a rosy hue, or a pale, yet not necrotic appearance. But little, if any exudation will have occurred, and if the granulating surface has been well covered in, scarcely any pus will be found. A gentle stream of the salt solution is allowed to trickle over the parts, and the dressing applied as before. After the first week, slight dusting with iodoform or subiodide of bismuth and a dry compress are to be substituted for the wet dressings. If a transplanted strip actually loosens and falls off a failure at that point does not necessarily result, for an island of epithelium is frequently found, and a good result follows. A bluish color indicates a collection of blood beneath the strip, which sometimes endangers its vitality, but does not always prevent its final adhesion. If, after a few applications of the dry compresses septic appearances occur, the salt water bandages must be again resorted to. After a week, the new formation tissue between the transplanted skin and the underlying surface is sufficiently advanced to resist the action of bacteria.

If the wound surface is not entirely covered, it frequently happens that an increase of secretion from the intermediate granulating surface occurs, which burrows its way under the edges of the adjoining transplanted strips, and prevents their adhesion. The outer layer of its epidermis forms blebs, which become filled with sero-pus, and this flows over the adjoining strips. This may happen to strips which have every appearance of being firmly adherent, and result in their being crowded away or becoming necrotic in situ.

It sometimes happens that the transplanted skin is broken through by the underlying granulations, and apparently the transplanted surface, in spots here and there, has broken down and is ulcerating. The portions of skin thus involved may disappear temporarily, to again make their appearance as the granulations recede. These so-called exuberant granulations may be the result of infection, but are far more likely to occur in cases where the transplantation is done in a stage of the granulating process too early for the reception of the trans-

planted skin, and in which there is still a very intense tissue-forming activity of the surface.

In those cases in which attempts are made to repair defects in the soft parts following necrotomy, disinfection of the parts is very difficult, and a large percentage of failures follow these attempts. In all cases of persistent failure in ordinary cases, the latter is probably due to infection, and measures to correct this are indicated. In cases suspected of a syphilitic taint the exhibition of iodides or a course of mercurial inunction will assist in clearing up the diagnosis. In fact, syphilis, and the presence of pus micrococci are the main obstacles to success. As just stated the former can be eliminated, while the presence of the latter is due to insufficient preliminary disinfection. Even exposed glandular and muscular tissue have been successfully covered. Attempts to remedy defects in location when tendons are lying uncovered, or spongy bone substance, are very uncertain in their results; the attempts to successfully cover bare compact bone, is quite likely to prove futile.

Within the first few weeks after a successful skin transplantation, the parts may present a peculiar mosaic appearance. This may be due to some extent to the fact that the pieces are thicker at the central portions than upon the edges. Insufficient covering of the surface of defect will also be responsible for this to a great extent. This, however, gradually disappears, and in any event is of but slight consequence, except in exposed situations, as for instance, the face.

The treatment of the point from which the skin has been removed will consist in simply dusting over the same with subiodide of bismuth or iodoform, dressing with a compress or sterilized gauze, and the application of a roller bandage. In the course of a week or ten days, the healing process is completed and that, too, without cicatrization. Successive portions of skin can be taken from the same point and successfully transplanted.

In transplantation of frog's skin, the same precautions should be observed in the preparation of the surface to be covered, and in its thorough disinfection and subsequent freeing from all traces of the germicide used. The frog to be used for the pur-

pose should be a healthy animal and as large as can be obtained. It is of advantage to keep it for several days in a vessel containing clean water, which should be changed from time to time. Just prior to the operation it is placed in the salt solution. Two shallow vessels containing the warm salt solution are in readiness and the instruments, after disinfection in hot water, are to be placed in one of these; the other is for the reception of the strips of skin as they are removed from the frog. A pair of dissecting forceps and scissors are the best instruments for removing the skin from the frog. The animal is held by an assistant by grasping its extremities and head, while the operator, pinching up a fold of skin, snips it through transversely to the long axis of the frog's body, and just behind its eyes, for from a quarter to half an inch, according to the size of the frog. This gives the width of the strip to be removed; the length will be governed by the steadiness with which the animal is held by the assistant. The skin of the frog is very loose, and readily strips away from the subjacent parts. The entire integumentary surface is to be removed in strips, including that of the fore legs, back, abdominal surface and lower extremities. As each strip is removed it is at once transferred to the warm salt solution, and, placed in situ upon the area of defect to be supplied as soon thereafter as possible, this being done, where practicable, by a third assistant. The same rule should apply here as in the operation for transplantation of human skin, *i. e.*, to cover the surface as completely as practicable and to leave as few and as narrow spaces between the strips of transplanted skin as possible.

Precisely the same methods of dressing and after treatment are employed as in case of transplantation of human skin. The daily dressing must be conducted with great care under a warm stream of the sterilized salt solution, in order to avoid disturbing the newly transplanted skin.

The first change noticeable in the transplanted frog's skin is the loss of its pigment. This takes place in from 7 to 10 days, and is most complete. The strips became perfectly diaphanous, and resemble wet tissue paper, the bright red granulating surface beneath showing through with great distinctness. The deeper shades of pigment are the last to disappear, and even

after 10 days, a tortuous streak of the same may be seen here and there. Gradually the strips assume the natural color of the skin of the white; in the colored individual the transplanted frog's skin, like the transplanted human skin, is not invaded by the pigment. In our present patient's case, this is noticeable. In the intermediate spaces where her own granulating tissue sprang up between the transplanted pieces both frog and human, the natural pigment staining is observed. Upon the left buttock, where the strip of skin taken from her own arm was placed, it will be noticed that the latter has maintained its pigmented aspect.

The most noticeable fact connected with the covering in of this large suppurating and granulating surface is the prompt and decided fall of temperature which ensued. Septic absorption ceased as soon as the natural vital resistance of the tissues was reinforced, and the granulations were perfectly protected from atmospheric influences.